MODELING AND UNDERSTANDING DIFFERENT TYPES OF PROCESS DESIGN ACTIVITIES

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Abstract— **One of the major tasks addressed by the chemical industry is the design and revamping of production processes. Increasingly powerful computer-aided tools are available to face these complex tasks. Nevertheless, most design knowledge still rests in the minds of experienced designers. It is desirable to make it part of a computer support environment. Therefore, it is necessary to have a model of the design process. This contribution addresses this objective by introducing a model, based on the identification of three types of design activities: *Synthesis*, *Analysis*, and *Decision*. We discuss the intrinsic characteristics of each type of activity from two different view points: characteristic subactivities and products. Every type of activity consists of typical subordinate subactivities which are distinctive for the type and determine its behavior. On the other hand, activities operate on the results or products of the design process, called product data, including requirements, the representation of the design artifact itself, and arguments. These products also allow a specification of the three types. These ideas are exemplified by modeling the design of a separation system.**

Keywords— **Design Process Modeling, Modeling Languages.**

I. INTRODUCTION

Design in process engineering is a very complex and not completely mastered activity. The challenges it raises have motivated a lot of research aiming at understanding, systemizing, and improving the design process. Han et al. (1996) proposed a methodology having three components: planner, scheduler, and designer. These authors distinguish four design tasks during every stage of the design process: Synthesis, Analysis, Evaluation, and Refinement. Synthesis is the activity of generating structural designs, while Analysis solves the material and energy balances for the synthesized structure. During Evaluation, the economic potential of the artifact being designed is calculated. Refinement is concerned with activities that allow the evolution from abstract to detailed models. We do not completely agree with this view but see Evaluation as a certain kind of Analysis; there is no conceptual difference between calculating a mass balance or an economic potential. In our view, Refinement of a model is a sequence consisting of *Synthesis* (*S*), *Analysis* (*A*), and *Decision* (*D*). In contrast to Han, we give a detailed characterization of these activities by specifying both their typical products and their distinctive subactivities. Linking activities are introduced which define the connection between the three main types of activities. Han's view of the design process is adapted from Douglas' (1988) hierarchical design procedure and does not directly apply to other design methodologies. It is limited to the synthesis of structural designs and focuses on the economic potential as a target function. This approach does neither take into account the refinement of a design and the underlying models across the design life cycle nor the modeling of design decisions and their underlying rationale. Precisely this last issue has been the aim of some other authors (King and Bañares-Alcántara, 1996; Ballinger et al, 1993; Brice and Johns, 1999) who recognize that design rationale should be a key component of the knowledge management strategy of any organization.

Depending on the domain and on the problem being addressed, design methodologies can vary. Boyle (1989) proposes a classification that splits design into three broad methodologies: analytical, procedural, and experimental design. Behind this classification is the concept of design objects, attributes of objects and operations on objects, as well as of the different roles that are assigned to humans and machines in these classes of design methods. The three categories proposed by Boyle can be summarized as follows:

(i) *Analytical or attribute centered design*, in which the attributes of the objects are used to determine the appropriate design actions. A design solution is automatically synthesized from the object attributes and the design objectives.